Dr. Reinhold Cohn
1899-1973
Ilan Cohn, *Ph.D. Biol.*
David Gilat, *B.Sc. Chem., LL.B, Adv.*
Jonathan J. Topper, *M.A. Elec. Eng.*
Ehud Hausman, *M.Sc. Comp. Sci., LL.B, Adv.*
David de Vries, *B.Sc. Mech. Eng.*
Ena Pugatsch, *M.Sc. Opt. Mech. Eng.*
Bossmat Gonen, *Ph.D. Biol.* Managing Partner
Svetlana Shtadler, *M.Sc. Phys.*
Jonathan Patinkin, *M.Sc. Biochem.*
Ben Spungin, *Ph.D. Biol. & Maths.*
Shulamit Hirsch, *Ph.D. Chem.*
Ronit Barzik-Soffer, *LL.B., Adv.*
Yigal Fraenkel, *Ph.D. Chem.*
Tamar Morag Sela, *M.Sc. Chem.*
Shelly Zohar, *LL.B., Adv.*
Odelia W. Or-Paz, *LL.M., Adv.*
Yitzhak Yogev, *Ph.D Chem.*
Einav Zilber, *LL.B. Adv,* B.Sc. Phys. *& Maths*
Daniella Atzmony, *Ph.D. Biol., LL.B. Adv*
Nick Kozlovich, *Ph.D. Phys. & Maths.*
Luiz Blanc, *LL.B., Adv.*
Orly Patz, *M.Sc. Chem.*
Vladimir Atanassov, *M.Sc. Hydro. & Aerodynamics*
Moshe Ohayon, *B.Sc. Applied Phys.*
Tamar Korakh, *M.Sc. Biol.*

Jerusalem, Shenhav House:
Tamar Gallily, *M.Sc. Biol.*
Ifat Katzhendler, *Ph.D. Pharm. Sci.*
Eyal Bressler, *Ph.D. Biotech.*
Naomi Helfand, *M.Sc. Biol.*
Gil Zecler, *CFO*
Michael Cohn, *Ph.D. Patent Attorney Consultant*
Israel Shachter, B.Sc. Patent Attorney, EPA Consultant
Oleg Korshunov, *M.Sc. Phys. Patent Attorney Consultant*

Reinhold Cohn House:
21 Ahad Ha'am St.
Tel Aviv 65151 Israel
P.O.B. 4060
Tel Aviv 61040 Israel
Tel: + 972 3 7109333
Fax:+ 972 3 5606405,
+ 972 3 5663782
Jerusalem, Shenhav House:
12 Beit Hadfus St.
Jerusalem 95483 Israel
P.O.B. 34335
Jerusalem 91342 Israel
Tel: + 972 2 6518880
Fax:+ 972 2 6523336
Website: www.rcip.co.il
e-mail: info@rcip.co.il

RC&P
Established 1934
Reinhold Cohn & Partners
Patent Attorneys

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<u>Attention: Mr. Herijgers, J</u>

EUROPEAN PATENT OFFICE
P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk –Pays Bas
The Netherlands

Dear Sirs,

Re: PCT Application No. PCT/IL02/01036
"Method and apparatus for controlling atmospheric conditions"
in the name of Yissum Research Development Company of the Hebrew University of Jerusalem
Inventors: Alexander KHAIN, Uri FELDMAN, Mark PINSKY, Vladimir ARTCHIPOV, Yaroslav RYABOV and Alexander PUZENKO
Our Ref: 140243-7 NK/dk

In response to the first Written Opinion mailed on June 18, 2003, enclosed please find substitute pages 5, 5a, 5b that include an amended background section to indicate document D1, together with pages 28-34, that include an amended set of claims, respectively. Also enclosed are original claims (pages 28-35), in which the amendments are indicated.

The following changes have been made in the claims:

Claims amended: 1, 6-10, 14, 16, 17, 19, 25, 30-34, 42, 48, 51, 61-63 and 66-70.

Independent claims 1 and 25 have been amended to clarify the essential features of the invention, and therefore more sharply distinguish it from the cited references. Claim 48 has been amended to indicate its dependency on claim 1 or 25. Claims 48, 51, 53-55, 61-63 and 66-70 have been amended to incorporate reference signs in parenthesis as per the requirements of Rule 6.2(b) PCT. Moreover, dependent claims 6-10, 14, 16, 17, 19, 30-34, 42 and 61 have been amended to clarify their dependency and various features of the invention. The introduced amendments do not go beyond the disclosure in the above referred-to application as filed, and they do not introduce any new matter. The originally filed specification fully supports the introduced amendments.

We refer now to the Examiner's objection of original claims 1 and 25 on the merits raised in paragraphs 2 and 8 of the Written Opinion, in which the Examiner states that these claims lack novelty over **D1** (U.S. Pat. No. 1,928,963). It is respectfully submitted that the amended claims overcome this objection for the following reasons.

Document **D1** describes a technique for dissolving clouds and fogs and producing rain by scattering charged particles in the atmosphere. It should be noted that besides the pioneering idea of utilizing charged particles for seeding clouds and fog, **D1** does not provide any practical solution for controlling the atmospheric conditions, owing to the fact that correct scientific understanding of the physical processes occurring in clouds and fog did not exist at the time when **D1** was filed and prosecuted (1925-1933).

In particular, **D1** mistakenly assumes that water droplets always repel each other when the charges of the droplets are all of the same sign. Therefore, for inducing collisions between the scattered particles and moisture particles of cloud and fog, **D1** teaches to seed the clouds and fog only by charged particles with a sign opposite to that of the moisture particles. **D1** underestimates the interaction between neutral and electrically charged droplets, which is very important, since the majority of water droplets is usually neutral in natural clouds and fog. Therefore, when clouds and fog are neutral, **D1** teaches first to charge the neutral cloud or fog with electricity of one polarity, by scattering seeding particles having a charge of one sign, and then treat it with particles of the opposite polarity (see page 1, lines 59-63 and claim 23). It should be appreciated by a person versed in the art that this suggestion is impractical, because not only can neutral water droplets be attracted to charged particles without their preliminary charging, but water droplets having the same sign can also be attracted for certain magnitudes of charges and droplet sizes.

the seeding elements are preferably charged with the same polarity charges (see claim 8). In all the cases, the charge magnitudes and polarity of the seeding elements should be calculated by using the collision model of the invention.

D1 does not even imply a method for controlling atmospheric conditions in a portion of the atmosphere in which the required polarity and charge magnitudes of the seeding particles could be calculated. Therefore, it is respectfully submitted that there is a substantial advantage in providing a collision model and algorithm with which the man of the art may calculate the magnitudes and polarity of the seeding particles required for desired coalescence and precipitation, without going through a trial and error or hit and miss procedure. None of the prior art documents provides such a model and algorithm, even though the methods for changing atmospheric conditions by producing rain-fall or the dispersal of clouds or fog by using charged particles has been known for over 70 decades. In this connection, it is noted that reference **D1** was published in 1933. Thus, in view of these circumstances, it is submitted that the present invention provides a significant inventive step over the prior art.

Therefore, it is deemed that the invention as defined in claims 1, 25 and 48 is novel and inventive over **D1**. Likewise, the dependent claims all relate to the method recited in claims 1, 25 or to the system recited in claim 48, which are deemed to be patentable over **D1**. Consequently, these claims are also deemed to be novel and patentable over this prior art document. Therefore, it is deemed that the invention, as defined in the claims, is both novel and inventive over the prior art document, and meets the requirements of Articles 33(2) to (4) PCT.

In accordance with the amendments in the claims and the above comments, reconsideration and withdrawal of the Examiner's objections are therefore respectfully requested. If the Examiner still has reservations, we would then appreciate the opportunity to further discuss the matter with the Examiner before issuing the International Preliminary Examination Report.

Yours very truly,
REINHOLD COHN AND PARTNERS
By:

Nick Kozlovich, Ph.D.
Patent Attorney

Encl.

Likewise, **D1** mistakenly assumes that one charged seeding particle can condense around it 30,000-40,000 moisture particles, with rapid consequent precipitation (see page 1, lines 53-59). Contrary to this assumption, in accordance with modern knowledge, one seeding particle cloud and/or fog cannot collect such a big number of droplets, because (i) the Coulomb force decays rapidly with the distance between the particle centers; and (ii) the magnitude of the collector charge decreases, due to collisions with oppositely charged moisture particles.

Moreover, no suggestion is made in **D1** as to how the sizes and charges of the moisture and seeding particles can effect the interaction of seeding particles and water droplets, and how this interaction can be varied for providing control of the collisions required for the droplet precipitation. Therefore, the method described in **D1** cannot provide reliable instructions for the error-free control of atmospheric conditions.

Contrary to **D1**, amended claims 1 and 25 recite a method that includes calculating a predetermined polarity and charge magnitude of seeding elements by using a collision model describing collisions between the charged seeding elements and the microscopic water droplets. Controlling the collisions can be achieved by altering an effective collision rate between the droplets that is proportional, *inter alia*, to a collision efficiency. The collision efficiency can be calculated by using computer simulations as described in the application on page 15, line 19 through page 17, lines 24. The calculation of the collision efficiency takes into account the charges and size distribution of the droplets and seeding elements. Examples of the calculation of the collision efficiency as a function of the charges and sizes of the droplets are shown in Fig. 4 for clouds and in Fig. 5 for fog.

In particular, in contrast to the teaching of the prior art, the collision efficiency for the smaller droplets (particles) for certain charge values can be higher than the collision efficiency for the larger droplets (particles). This unexpected result provides an advantage of the method of the present invention that was unappreciated hitherto. As was mentioned in the background section of the application, one of the major requirements of the prior art techniques was the production of large seed particles, since the small particles are not effective for creating large drop-collectors. In particular, the techniques based on seeding combustion products obtained by burning are not sufficiently effective, since the combustion product contains mainly small particles. Thus, the main drawback of the prior art technique that militates against the use of small seed particles is overcome by the invention, and actually used to advantage.

Moreover, the method of the present invention allows, *inter alia*, controlling the values of the desired visibility in fog (see, for example, Fig. 7), and the relative rainwater content in clouds (see, for example, Fig. 8). In particular, according to the invention, in order to obtain fast increase of visibility in fog, the seeding elements are preferably charged with the opposite polarity charges (see claim 7). In turn, in order to obtain the maximum rain enhancement,

CLAIMS:

1. A method of controlling atmospheric conditions in a portion of the atmosphere containing microscopic water droplets dispersed therein so as to produce their desired coalescence and precipitation, the method includes:

(a) providing a predetermined amount of a seeding material having uncharged seeding elements of a predetermined size distribution;

(b) calculating a predetermined polarity and charge magnitude of seeding elements by using a collision model describing collisions between said charged seeding elements and said microscopic water droplets;

(c) electrically charging the uncharged seeding elements so as to produce charged seeding elements having said predetermined polarity and charge magnitude, and

(d) seeding said charged seeding elements in said portion of the atmosphere.

2. The method of claim 1 wherein said portion of the atmosphere is a portion of cloud.

3. The method of claim 1 wherein said portion of the atmosphere is a portion of fog.

4. The method of claim 1 wherein said droplets are substantially electrically neutral.

5. The method of claim 1 wherein said droplets are electrically charged.

6. The method of claim 1 wherein the calculating of the polarity and charge magnitude of the seeding elements by using a collision model takes into account said size distribution of the water droplets in said portion of the atmosphere.

7. The method of claim 3 wherein said seeding elements are charged with opposite polarity charges.

8. The method of claim 2 wherein seeding elements are charged with the same polarity charges.

9. The method of claim 1 wherein said seeding material includes particles of a particulate material.

10. The method of claim 1 wherein said seeding material includes atmospheric water droplets.

11. The method of claim 9 wherein the providing of the particulate material includes burning a pyrotechnic material.

12. The method of claim 9 wherein the particles are soot particles.

13. The method of claim 9 wherein the particulate material is a powdered solid material.

14. The method of claim 1 wherein said seeding elements have a spread of sizes ranging from sub-micron to several micron sizes.

15. The method of claim 14 wherein the size of said seeding elements ranges from 0.1 micron to 20 microns.

16. The method of claim 1 wherein the charge magnitude of the charged seeding elements ranges from about $\pm 10^{-16}$ Coulomb to about $\pm 10^{-12}$ Coulomb.

17. The method of claim 1 wherein the electrically charging of the seeding elements comprising passing the particles through an electric discharge of a predetermined discharge characteristic.

18. The method of claim 17 wherein said electric discharge is corona discharge.

19. The method of claim 1 wherein an effective collision rate in said collision model is proportional at least to a collision efficiency and a concentration of the droplets.

20. The method of claim 19 wherein said collision efficiency has a value higher than 1.

21. The method of claim 19 wherein said collision efficiency ranges from 0.001 to 100.

22. The method of claim 1 wherein the controlling of the atmospheric conditions is effected from a flying object.

23. The method of claim 1 wherein the controlling of the atmospheric conditions is effected from a ground located source.

24. The method of claim 23 wherein the ground located source is a chimney stack.

25. A method of controlling atmospheric conditions in a portion of the atmosphere containing microscopic water droplets so as to cause their coalescence and precipitation, the method characterized by:

adjusting non-gravitational attraction forces between the droplets to a predetermined value so as to alter an effective collision rate between the water droplets, where said adjusting of the non-gravitational attraction forces includes:

(One) providing a predetermined amount of a seeding material having uncharged seeding elements of a predetermined size distribution;

(Two) calculating a predetermined polarity and charge magnitude of seeding elements by using a collision model describing collisions between said charged seeding elements and said microscopic water droplets;

(Three) electrically charging the uncharged seeding elements so as to produce charged seeding elements having said predetermined polarity and charge magnitude, and

(Four) seeding said charged seeding elements in said portion of the atmosphere.

26. The method of claim 25 wherein said portion of the atmosphere is a portion of cloud.

27. The method of claim 25 wherein said portion of the atmosphere is a portion of fog.

28. The method of claim 25 wherein said droplets are substantially electrically neutral.

29. The method of claim 25 wherein said droplets are electrically charged.

30. A method of claim 25 wherein the calculating of the polarity and charge magnitude of the seeding elements by using a collision model takes into account said size distribution of the water droplets in said portion of the atmosphere.

31. The method of claim 27 wherein said seeding elements are charged with opposite polarity charges.

32. The method of claim 26 wherein said seeding elements are charged with the same polarity charges.

33. The method of claim 25 wherein said seeding material includes particles of a particulate material.

34. The method of claim 25 wherein said seeding material includes atmospheric water droplets.

35. The method of claim 33 wherein the providing of the particulate material includes burning a pyrotechnic material.

36. The method of claim 33 wherein the particles are soot particles.

37. The method of claim 33 wherein said particulate material is a powdered solid material.

38. The method of claim 25 wherein the seeding elements have a spread of sizes ranging from sub-micron to several micron sizes.

39. The method of claim 25 wherein the charge magnitude of the charged seeding elements ranges from about $\pm 10^{-16}$ Coulomb to about $\pm 10^{-12}$ Coulomb.

40. The method of claim 25 wherein the electrically charging of the seeding elements comprising passing the particles through an electric discharge of a predetermined discharge characteristic.

41. The method of claim 40 wherein said electric discharge is corona discharge.

42. The method of claim 25 said effective collision rate is proportional at least to a collision efficiency and a concentration of the droplets.

43. The method of claim 42 wherein said collision efficiency has a value higher than 1.

44. The method of claim 42 wherein said collision efficiency ranges from 0.001 to 100.

45. The method of claim 25 wherein the controlling of the atmospheric conditions is effected from a flying object.

46. The method of claim 25 wherein the controlling of the atmospheric conditions is effected from a ground located source.

47. The method of claim 46 wherein said ground located source is a chimney stack.

48. An apparatus for controlling atmospheric conditions in a portion of the atmosphere **(66)** containing microscopic water droplets dispersed therein by carrying out the method of claim 1 or 25, the apparatus comprising:

a chamber **(61)** for providing an element flow stream of a seeding material containing uncharged seeding elements having a predetermined size;

a charger **(62)** downstream of the chamber **(61)** and in communication therewith for charging said uncharged seeding elements in said element flow stream so as to produce charged seeding elements having a predetermined polarity and charge magnitude;

a seeder **(65)** for controllable scattering said charged seeding elements in said portion of the atmosphere;

a control module **(67)** for controlling operation of the apparatus; and

an electrical power source **(80)** for providing electrical power required for operation of the apparatus.

49. The apparatus of claim 48 wherein said seeding material includes particles of a particulate material.

50. The apparatus of claim 48 wherein said seeding material includes atmospheric water droplets.

51. The apparatus of claim 49 wherein the chamber comprising:

a feeder **(620)** for allowing introduction of a raw material of a required kind in a required amount,

a mixer **(610)** for mixing an air flow stream with a predetermined amount of the particulate material derived from said raw material, thereby producing said element flow stream,

an outlet **(72)** for releasing said element flow stream.

52. The apparatus of claim 49 further comprising a fan for providing said air flow stream.

53. The apparatus of claim 49 further comprising a burner **(630)** coupled to the chamber for burning said raw material so as to form the particulate material as a combustion product.

54. The apparatus of claim 48 wherein said portion of the atmosphere **(66)** is a portion of cloud.

55. The apparatus of claim 48 wherein said portion of the atmosphere **(66)** is a portion of fog.

56. The apparatus of claim 48 wherein said droplets are substantially electrically neutral.

57. The apparatus of claim 49 wherein the particulate material is a powder.

58. The apparatus of claim 53 wherein said combustion product is soot particles.

59. The apparatus of claim 48 wherein the seeding elements have a spread of sizes ranging from sub-micron to several micron sizes.

60. The apparatus of claim 48 wherein the value of the charge of the seeding elements ranging from about $\pm 10^{-16}$ Coulomb to about $\pm 10^{-12}$ Coulomb.

61. The apparatus of claim 49 wherein said fan for providing said air flow stream is arranged in the mixer **(61)**.

62. The apparatus of claim 48 wherein said chamber includes an inlet **(621)** for receiving an input air flow stream from atmosphere and transferring the input air flow stream to the chamber **(61)** thereby providing said air flow stream.

63. The apparatus of claim 62 further including a suction device **(690)** arranged in said inlet **(621)**.

64. The apparatus of claim 48 wherein the charger comprises at least a pair of electrodes for producing an electric field.

65. The apparatus of claim 48 wherein the charger comprises at least a pair of electrodes for producing an electric discharge.

66. The apparatus of claim 62 wherein said control module includes a first strain regulator **(81)** arranged in the inlet **(621)** for producing a first sensor signal representative of a strain of the air in the air flow stream **(68)**, the control module being responsive to said first sensor signal for controlling the strain.

67. The apparatus of claim 48 wherein said control module **(67)** includes a second strain regulator **(82)** arranged in the outlet **(72)** for producing a second sensor signal representative of a strain of the element flow stream **(63)**, the control module **(67)** being responsive to said second sensor signal for controlling the strain.

68. The apparatus of claim 48 wherein said control module **(67)** includes a third strain regulator **(83)** arranged in the seeder **(65)** for producing a third sensor signal representative of a strain of the charged element flow stream **(70)**, the control module **(67)** being responsive to said third sensor signal for controlling the strain.

69. The apparatus of claim 53 wherein said control module **(67)** includes a temperature regulator **(85)** arranged in the chamber **(61)** and is responsive to a signal produced thereby for controlling temperature in the burner **(630)**.

70. The apparatus of claim 48 wherein said control module **(67)** includes a charge regulator **(84)** arranged in the charger **(62)** and is responsive to a signal produced thereby for controlling the charge magnitude and/or polarity of the charged particles.

71. The apparatus of claim 48 for use with a flying object.

72. The apparatus of claim 48 for use with a ground located source.

73. The apparatus of claim 72 wherein said ground located source is a chimney-stalk.

74. Rain obtainable by the method of claim 1.